

# Prehospital Medication Errors

John D. Hoyle, Jr. MD, FACEP, FAAP

Associate Medical Director, Helen DeVos

Children's Hospital Emergency Dept

Associate Professor, MSU Division of Emergency  
Medicine

# Conflict of Interest Disclosure

- I am an inventor and hold the U.S. patent on a drug dosing device.

# Goals and Objectives

## Goals

1. Understand the history of medical errors
2. Understand the different types of medical errors
3. Understand the incidence of prehospital pediatric drug dosing errors

## Objectives

1. Be able to discuss the types of drug errors
2. Be able to cite common points for errors to occur
3. Be able to discuss tools and systems you can use to prevent error

# Background

- Children are especially vulnerable to drug-dosing errors
- It is well known that drug-dosing errors occur throughout the hospital-based health care system at a rate of 1-11%.
- However, the incidence of drug-dosing errors in pediatric patients cared for by Emergency Medical Services is relatively unknown.

# What is a Medical Error?

- Medical Errors: Any error that occurs in medicine and has the potential to harm a patient
  - Medication errors
  - Diagnosis errors
  - Identification errors
  - Procedural errors
  - Errors of Omission
  - Errors of Commission

- Wrong dose
  - More likely to occur in pediatric patients
- Wrong drug
- Wrong route
  - IM instead of IV
- Wrong rate of administration
- Wrong concentration of drug
  - Epi 1:1000 vs 1:10,000
- Drug given to patient despite documented allergy
- Drug interaction
  - i.e. nitro and viagra

- 1999 Institute of Medicine (IOM) report:
  - 3-4% of hospitalized patients are harmed by the health care system
  - 7% of hospitalized patients are exposed to a serious medication error
  - 50,000 – 100,000 deaths/ yr from medical mistakes
    - Equivalent of 280 747s crashing in a year with no survivors
      - 1 every 1.3 days
      - One every 30 hours
    - Would that get you attention?

# Institute of Medicine Report

- What was medicine's reaction?
  - Shock
  - Met with a lot of controversy (i.e DENIAL)
  - Few in medicine believed this could be happening.
  - Egos and pride were severely bruised and bloodied.
- But eventually we grieved and moved on to acceptance...



# What happened after IOM?

- Medicine looked to high reliability organizations (commercial aviation, nuclear energy, military) for models of how to decrease errors

# High Reliability Organizations

- Definition: HROs are those organizations that function in hazardous, fast-paced, and highly complex technological systems essentially error-free for long periods of time.
  - Essential Characteristic: Preoccupation with failure

# HRO Characteristics

- Highly trained-personnel, continuous training
- Frequent process audits
- Continuous improvement efforts.
- Widely distributed sense of responsibility & accountability for reliability
- Widespread concern about misperception, misconception and misunderstanding
- Pessimism about possible failures
- Redundancy and a variety of checks and counter checks (safety systems)

# Systems and errors

- “Medical mistakes are merely human mistakes committed within a human system inadequately designed to catch and neutralize those mistakes”
- “Every system is perfectly designed to get the results it consistently achieves.”

Why Hospitals Should Fly John Nance JD

# Swiss Cheese Model of Error

Reason, James. Human error: models and management. British Medical Journal 2000; 320:768-770.

# Faulty System

# What happened after IOM?

- More research into how to stop errors from reaching patients
  - Because we're human errors will still happen
  - Errors need to be trapped by systems
- Research in prehospital arena will be the key to decreasing errors.
  - Research as to why errors occur
  - Research on what processes reduce error rate

# Routine Hospital Drug

- Physician enters order in computer for patient
  - Computer:
    - Checks that entered weight is appropriate for age
    - Calculates dose for weight and checks dose against child's weight to assure it is correct
- Order goes to pharmacist who checks dose/ mixes drug
- Drug is bar-coded with patient's name, drug dose
  - Pharmacy tech takes drug to nurse
- Nurse scans drug & patient's ID band
  - Scanner confirms right drug and right patient
  - Nurse double checks pt name and drug



# Hospital Code Drug

- Broselow tape used to determine pt weight
- Code sheet for that weight gives dose in ml
- Pharmacist draws up medication
- Doctor, Nurse and Pharmacist “check back”
- Dose is delivered to pt



# Drug prehospital

- EMTP determines drug to be given
- EMTP calculates dose
  - With or without computer?
  - May consult protocol
  - May use drug dosing aid (Broselow tape)
- EMTP draws up dose or grabs bristojet
- EMTP administers drug

# Emergency Medicine Errors

- Marcin, et al Annals of Emerg Med 10/07
  - Examined medication errors in 4 rural EDs in CA
    - Drug dosing errors: 11.1% of 135 pts
      - 5.9% overdoses
      - 5.2% under doses
    - Wrong drug for condition: 3.0%
    - Wrong route: 3.0%
    - Med given but not ordered: 29.6%
    - Med ordered but not given: 13.3%

# Emergency Medicine Errors

- Kozer, et al Pediatrics October, 2002
  - Examined 1532 children in one Pediatric ED
    - 133/ 1678 (7.9%) drug doses were wrong
    - 7/ 1678 (0.42%) wrong route
    - 5/ 1678 (0.3%) wrong drug
  - Error more likely to occur:
    - Between 4 am and 8 am
    - Patients with severe disease
    - Med ordered by a trainee
    - On weekends

# What about prehospital errors?

- To what degree do errors occur in the prehospital/EMS environment?
- Prehospital unique challenges
  - Limited personnel
  - Limited resources
  - Scene chaos

# What about prehospital errors?

- RN/ EMT-P and RN/ MD flight crews Indianapolis mid 1990s
- 1 day to 14 years age group
  - Atropine & epinephrine doses were incorrect up to 42%
  - Sedation and pain meds incorrect 0-77%
  - Succinylcholine incorrect 44%

# Prehospital Errors

- Kaji, et al Pediatrics, October 2006
- LA County Paramedics
- 1994-1997 epinephrine dose error: 65.8% incorrect
  - Fewer errors when Broselow tape used.
- Extensive quality improvement program to decrease error
- 2003-2004 epinephrine dose error: 35% incorrect

# Prehospital Errors

- Lammers, Fales, et al Academic Emerg Med 2007
- EMTPs completed pediatric patient simulation scenarios
- Epinephrine dose incorrect: 68-73%
- Failure to use Broselow tape: 50%
- Incorrect use of Broselow tape: 47%



# Prehospital Pediatric Medication Error

- The three studies I mentioned are the only ones looking at prehospital medication errors
- That led our team to look into the error rate in patients card for by EMS.
- Preliminary findings that have been presented

# Study Objective

To identify the incidence of drug-dosing errors in pediatric patients treated by Emergency Medical Services (EMS)

# Methods

## ***Design:***

- Retrospective observational cohort
- Michigan Emergency Records Management and Information Database (MERMaID)
- Data from 9 EMS agencies were examined
  - Serve 10% of Michigan's population (1,009,500 persons)
  - Serve a demographically diverse population
- MERMaID data from 2004, 2005 and the first quarter (January through March) of 2006
- Received designation as a Medical Research Project from the Michigan Department of Community Health

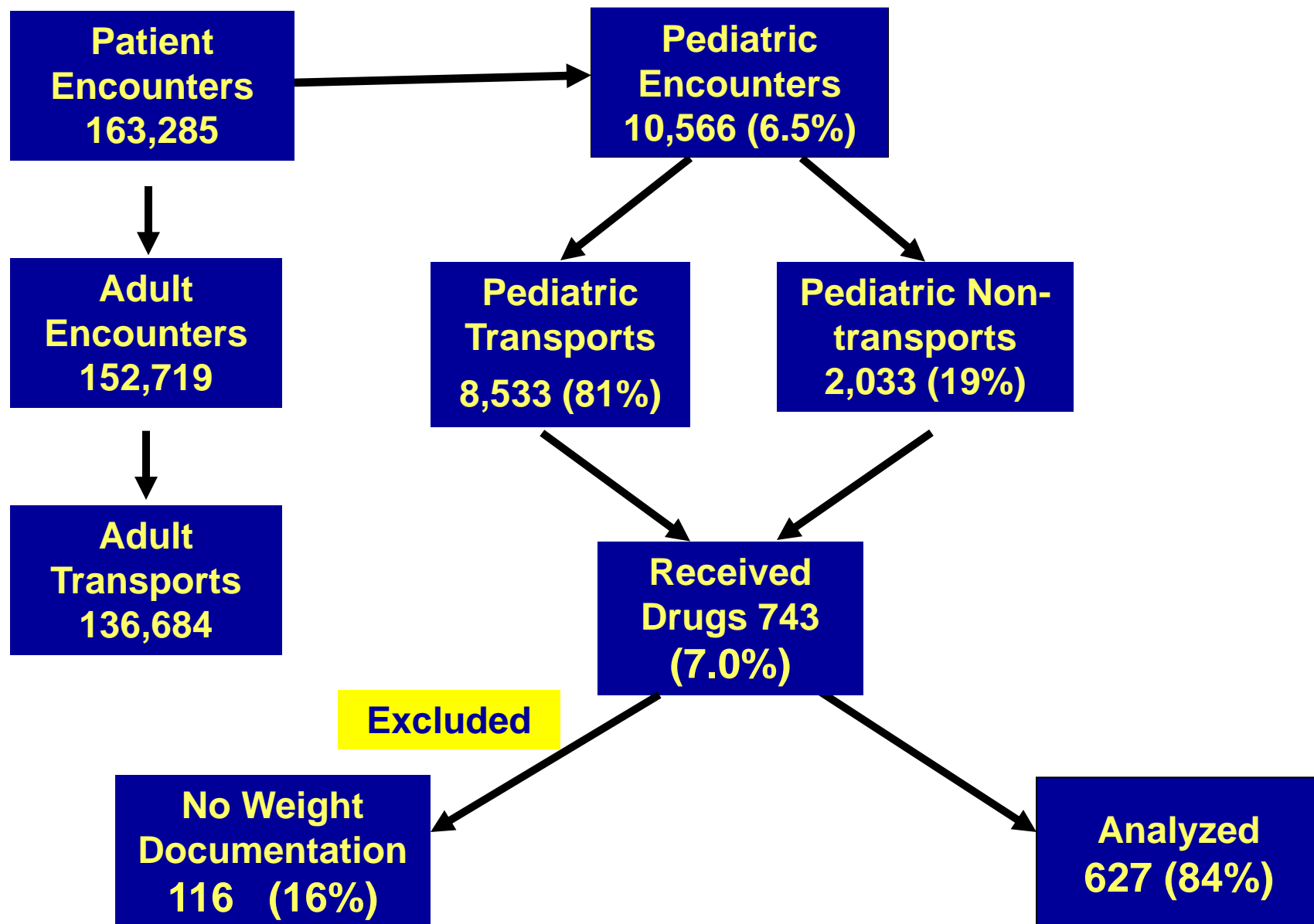
# Methods

- ***Inclusion Criteria:***
  - $\leq 17$  years of age
  - Scene runs
  - Interhospital transfers
- ***Exclusion Criteria:***
  - Patients without a documented weight or Broselow tape color
  - Drugs administered  $\leq 10$  times were excluded from this analysis

# Methods

- Standards for correct drug doses were based on Michigan's model EMS pediatric protocols
- Error was defined as  $> 10\%$  difference in dose from the protocol standard based on the patient's documented weight or Broselow tape color
- Data collected included age, weight or Broselow tape color, and all drug doses administered

# Results



# Results

- For the 10,566 patient encounters:
  - Patient mean age:  $9.7 \pm 0.1$  years
  - 63.5% were male
- 56.5% of all drug doses were incorrect

# Results

- 213/425 (50.1%) of paramedics did not administer a drug to a pediatric patient during the study period.
  - Average number of drugs administered by individual paramedics for the study period: 5.25
  - 2.3 per year
- In patients  $\leq 12$  years, weight determination via Broselow tape was documented in 41/336 (12.2%).



# Results

Drug	# Correct/ Total	% Correct (95%CI)
Albuterol	315/383	82.2% (78.0-85.7)
Atropine	56/83	67.5% (56.8-76.6)
Naloxone	16/34	47.1% (31.4-63.4)
Diphenhydramine	15/35	42.9% (28.0-59.1)
Epinephrine	35/128	27.3% (20.4-35.6)
Diazepam	10/40	25.0% (14.2-40.2)
Midazolam	15/63	23.8% (15.0-35.7)
Dextrose	7/38	18.4% (9.2-33.4)
Morphine	17/314	5.4% (3.4-8.5)

# Drug Overdoses

Drug	# Overdoses	Mean error (%) $\pm$ SEM
Albuterol	9	182 $\pm$ 12
Atropine	12	576 $\pm$ 120
Epinephrine (all routes)	24	415 $\pm$ 71
Epinephrine IV/IO 1:1,000	9	433 $\pm$ 147
Morphine	3	139 $\pm$ 14
Dextrose	5	188 $\pm$ 20
Midazolam	29	205 $\pm$ 22

# Drug Under doses

Drug	# Under doses	Mean error (%) $\pm$ SEM
Albuterol	59	48.4 $\pm$ 1.5
Atropine	15	46.7 $\pm$ 0.0
Epinephrine (all routes)	69	27.7 $\pm$ 2.7
Epinephrine IV/IO 1:1,000	25	28.7 $\pm$ 4.9
Morphine	294	41.6 $\pm$ 0.0
Dextrose	26	63.5 $\pm$ 3.8
Midazolam	19	54.0 $\pm$ 0.1

# Epi all routes

Concentration / Route	# Correct/ Total	Percent correct
1:1,000 IM / SQ	9/13	69.2%
1:1,000 ETT	1/22	4.5%
1:10,000 IV	7/33	21.2%
1:1,000 IV	7/24	29.2%

# Did Broselow Tape Help?

Drug	Dose (#)	Correct (# / %)
Albuterol	12	9 / 75%
Atropine	30	17 / 56%
Epinephrine	50	16 / 32%
Midazolam	5	0 / 0%
Morphine	1	0 / 0%

# Where/ How can an error occur?

Wt x dose = mg → ml → deliver to pt

How often do you do this?

How often do you practice this?

Do all this under the most stress you'll ever be under

- sick/critically ill child
- parent's/ care givers stressed
- poor working conditions

# Dextrose

- **Dose:** 0.2 - 0.5 gm/kg
- **Available As:** D<sub>25</sub> (0.25 gm/ml) or D<sub>50</sub> (0.5gm/ml)
- **Calculation:**
  - Pt Weight x 0.5 gm/kg ÷ 0.25 gm/ml = dose
- **Or:** 2-4 ml/kg of D<sub>25</sub>

# With all of these opportunities for error can any of us get it right?

- Correct dose requires complicated string of events
- Individual may not experience such a patient in  $\geq 2$  years
- High stress situation
- Aids such as Broselow tape simplify things but still aren't perfect



# Broselow Tape

- ***Can*** be very helpful
- Has to be used to work
- Frequently used upside down (“RED to HEAD”)
- **Still requires mg to ml conversion**

# How do we fix this?

- EMT-Ps and EMS medical directors need to put systems/ technology in place to help reduce errors
  - We haven't given you the tools you need to perform well with an infrequent event
- In the hospital:
  - Computerized order entry
  - Pharmacists checks
  - Automatic allergy flags
- Prehospital
  - None of these available

# How do we fix this

- Requires a change of our culture!
  - Accept that we are human and humans make mistakes
  - Errors need to be treated as a system failure and not a failure of the person that made them
  - Errors need to be freely reported, without repercussions so that the system can be corrected
  - Systems need to be designed, specifically for EMS to decrease the incidence of medical errors
  - Treat every drug admin as if it's wrong and will kill the patient (John Nance)

# How do we fix this?

- My recommendations:
  - Look at the Broselow tape at the start of every shift
  - Use Broselow tape on every child
    - If you have questions, ask your medical director or an EM doctor
  - Have your agency make a reference book with all the doses for all the weights on the Broselow tape in ml
    - Has to be standardized to the drug concentrations you use!!
    - May not be valid if you get replacement drugs outside of your system

# How do we fix this?

- Regular (monthly) pediatric mock codes/ cases
- Encourage PALS review at least twice a month
- Immediate feed back from Medical Director on all pediatric cases
  - Review your doses/calculations: were they correct?
- Check back all of your drug doses EMTP partner
- Encourage your EMTPs to trouble shoot and offer solutions
- Law of unintended consequences.

# How do we fix this?

- Research!
  - Drs. Rick Lammers and Bill Fales from Kzoo
    - Running patient simulations with EMTPs to see why errors occur
  - Pediatric Emergency Care Applied Research Network (PECARN)
    - 21 hospital federally funded network tasked with doing definitive studies on Peds Emergency Medicine topics
      - We are actively setting up the framework to carry out studies in the prehospital setting
  - We'll need your help and participation

# Conclusions

- Pediatric drug dosing errors occur everywhere
- They occur at a very high rate in the prehospital environment
  - Contributing factors:
    - Infrequent pediatric patient exposure
    - Infrequent practice of drug calculations
      - Lack of exposure and practice is a set up for errors to occur
    - Lack of error prevention systems in place for EMS
    - Prehospital environment is unique and chaotic

# Conclusions

- Now is the time to begin solving this problem for EMS and your pediatric patients
- Will take all involved to fix this
- Will require creative thinking
  - The prehospital environment is very different vs hospital
- For now:
  - Use the Broselow tape (practice , practice, practice)
  - Do regular pediatric mock codes and cases
  - How can you avoid calculations?



# How do we fix this?

- Recommendations from the Audience
  - What are the issues for you with delivering correct drug doses to children
  - What are you doing that works?
  - What are the barriers to fixing this?

# Thanks